ANALYTICAL STUDY ON DESIGN AND DEVELOPMENT OF HERICHAL CLUSTERING USING ADHS ALGORITHM

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ABSTRACT-Wireless sensor networks (WSN) play a pivotal role in various applications, including healthcare monitoring, mobile phones, military operations, disaster management, and surveillance systems. Sensor nodes are typically deployed in large numbers, operating autonomously in harsh and unattended environments. In this paper, provide a comprehensive and detailed examination of clustering routing protocols proposed in the literature for WSNs. We outline the advantages and objectives of clustering in WSNs and establish a novel taxonomy of WSN clustering routing strategies based on comprehensive and detailed clustering properties. Furthermore, we extend this algorithm to formulate a hierarchy of cluster heads and observe that the energy savings increase with the number of levels in the hierarchy. Stochastic geometry results are employed to derive solutions for the parameter values of our algorithm, aiming to minimize the overall energy expenditure in the network when all sensors transmit data through the cluster heads to the processing center. This research contributes to a deeper understanding of clustering routing protocols in WSNs and provides insights into the energy-efficient organization of sensor nodes in hierarchical structures.
Keywords: Wibreless, Clustering, Hierarchy, Parameters

I. Introduction

The wireless sensor network comprises wireless nodes typically deployed randomly in a targeted area within dynamically changing environments. These nodes can detect, process, and transmit data to neighboring nodes and base stations (BS), equipped with limited capabilities such as small memory, low computation, low processing power, and notably, a small power unit (usually powered by batteries). Deployed across a vast geographic area containing numerous nodes, the WSN is essential for monitoring specific regions. As the detected data needs to be forwarded to the BS for further processing, efficient routing becomes crucial for the seamless transmission of data between nodes or from nodes to the BS.

WSN has been identified as a significant technology of the 21st century, where small, cost-effective devices with onboard sensors, wirelessly connected with self-organizing capabilities, can be linked to the Internet for monitoring and controlling environments, homes, offices, cities, and more. These sensor nodes can be deployed anywhere, including on the ground, underwater, on bodies (WBAN—Wireless Body Area Network), in the air, within buildings, and even in vehicles (VANETs—Vehicular Ad Hoc Networks).

To optimize available resources, especially battery power, various hierarchical strategies have been proposed in WSN. The primary goal is to achieve energy efficiency and extend the network's lifetime. Clustering is the most widely used technique in hierarchical routing to attain these objectives. Clustering schemes eliminate redundant information from efficient clusters and involve intelligent selection/reselection of the Cluster Head (CH). While various clustering protocols have been proposed in the literature, challenges such as optimizing energy efficiency and load balancing require further research. Additionally, topology formation is crucial to maintaining nodes consistently in clusters or grids in the case of grid-based approaches, ensuring the network's efficiency.

However, the periodic reformation of clusters and reselection of CHs result in unnecessary energy consumption, potentially leading to poor network performance. Routing in wireless sensor networks is more challenging than other wireless networks due to resource limitations. New routing mechanisms are being developed to address these challenges while considering application requirements and the underlying network architecture. To minimize energy consumption and prolong the overall network lifetime, various routing strategies have been introduced, broadly categorized into four classes: network structure, topology-based, robust routing design, and communication model design. The focus of this work is on the highlighted subcategories within these classes. Network structure is further classified into flat and hierarchical protocols. In flat networks, all sensor nodes interact through multi-hop routing with each node having the same role. However, flat networks use flooding, an energy-intensive operation. Moreover, they lead to high bandwidth usage due to redundant messages and exhibit non-uniform energy consumption with high delays**.**

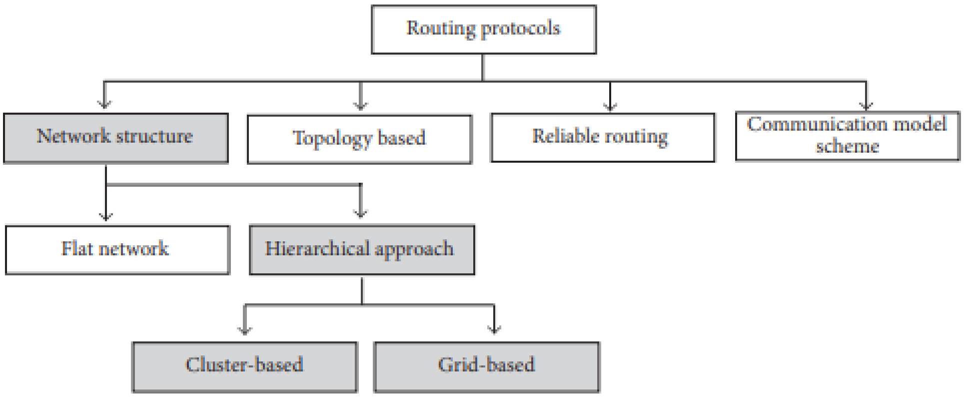

Figure 1: Classification of routing protocols in WSN.

In hierarchical approaches, nodes are grouped into clusters, and a cluster head is selected based on specific criteria to manage routing responsibilities. Hierarchical routing typically involves a two-layer approach: one layer for sensing the physical environment and another for routing. Low-energy nodes handle sensing, while high-energy nodes are often employed for clustering, aggregating, and transmitting data. The clustering approach, widely adopted for energy efficiency, aims to achieve scalability and effective communication.

Cluster-based hierarchical approaches offer several advantages, such as enhanced scalability and efficient utilization of data aggregation and channel bandwidth. However, a significant challenge is non-uniform clustering, leading to uneven energy distribution among sensor nodes, increased overall energy consumption, and potential issues with network connectivity assurance. This work focuses on hierarchical clustering schemes.

The primary contribution of this study is to provide an overview of existing energy-efficient hierarchical clustering approaches, categorized into cluster-based and matrix-based techniques based on network structure. The central focus revolves around cluster formation, cluster head selection, cluster reorganization, and cluster head reselection, taking into account their impact on energy consumption and overall network lifetime. Additionally, the advantages and disadvantages of both hierarchical approaches are discussed, presenting a detailed summary to assist researchers and practitioners in choosing the most suitable method based on application requirements. It's important to note that this work exclusively concentrates on hierarchical energy-efficient clustering protocols

WSN Hierarchical Clustering

Nodes in multi-bounce specially appointed sensor networks assume a double job as a data originator and data switch simultaneously. A portion of the nodes may not work appropriately, which may prompt major topological changes and require the rerouting of certain parcels and network reproduction. This further stresses the significance of energy efficiency and energy control. Along these lines, the focal point of numerous analysts of WSN is to create protocols and calculations that consider scalability and energy efficiency by gathering the network nodes into clusters so as to frame a hierarchical topology and taking out any excess data. This procedure comprises of the accompanying advances: Nodes transmit their detected data to an ace node; The ace node totals the data; The ace node performs calculations on the data and disposes of the pointless data; The ace node advances the recently determined data to the sink node.

A formalized way to deal with the show this idea accepts that a WSN cluster comprises of the accompanying primary segments: a base station (BS) and various sub-clusters. Every one of the sub-clusters has a pioneer (ordinarily alluded to as the cluster-head, or CH), just as different nodes (non-cluster-head nodes, or NCH) that are all inside a similar transmission go. The transmission run is characterized as the maximal separation between a recipient and a sender (for this situation, CH and NCH individually). There is a connection between's the length of the transmission run and the energy expended in this topology. Various propelled transmitter units can alter the transmission energy consumption factor in a dynamic and versatile way, so as to empower energy sparing in the consumption required to move toward close by recipients. This accessible low power transmission rates may diminish unsettling influence, which thusly builds the network throughput. However, one of the confinements of a low energy rate can be found in the availability of the network - on the off chance that the energy transmission rate is low; at that point every node may have less legitimately agreeable nodes. It merits referencing that the techniques accessible for this sort of energy conservation work exclusively on the connection layer and don't hurt the data processing employments performed by a node, rather than rest cycle lead.

II. Literature Review

Arboleda et al. [2006] introduced a correlation study between various clustering protocols. The creators of the overview talked about some fundamental ideas identified with the clustering procedure, for example, cluster structure, cluster types, clustering advantages, and quickly dissected LEACH-based protocols just as proactive and responsive calculations in WSNs. The fundamental qualities of these protocols were analyzed and the proof where they can be utilized at present was plot.

Kumarawadu et al. [2008] overviewed the clustering calculations accessible for WSNs and classified them dependent on the cluster arrangement parameters and CH choice criteria. The creators of the study likewise examined the key design difficulties and talked about the performance issues identified with clustering protocols dependent on the classification of character based clustering calculations, neighborhood information-based clustering calculations, probabilistic clustering calculations, and biologically roused clustering calculations.

Jiang et al. [2009] examined a sum of three unmistakable advantages of clustering techniques for WSNs, for example, greater scalability, less overheads, and simple support, and afterward present a classification of WSN clustering schemes dependent on a sum of eight clustering properties. The creators additionally broke down by and large six prevalent WSN clustering calculations, for example, LEACH, PEGASIS, HEED, EEUC, and so on., and analyzed these WSN clustering calculations, including different qualities.

Xu et al. [2011] have made a straightforward study of clustering routing protocols, including just six normal clustering calculations. The creators of the review basically analyzed these clustering routing calculations dependent on some performance parameters, including energy preservation, network lifetime, data accumulation, strength, scalability, security, and so forth

Haneef and Deng [2012] centers around design difficulties and relative investigation of WSN clustering routing calculations for improving the network lifetime. The creators of the diagram broke down many testing factors that impacted the design of routing protocols in WSNs and exhibited a basic classification of routing protocols. In addition, numerous efficient clustering-based old style WSN routing protocols with similar investigation were examined in the diagram.

Design Challenges in Clustering

Wireless sensor network exhibits a few difficulties with respect to the design and usage of clustering calculations. In the vast majority of the WSN open-air applications in unattended situations, it is difficult to revive the battery or supplant the whole sensor. Because of restricted equipment, the processing capacities additionally should be considered. A lightweight clustering calculation is required due to restricted memory. Besides, with these limitations, it is hard to oversee scalability and draw out the network's lifetime. Alongside the previously mentioned impediments, coming up next are some different moves that should be tended to appropriately while designing clustering calculations. The cluster development process and the number of clusters are significant factors in clustering protocols. The clusters ought to be very much adjusted, and the number of messages traded during cluster development ought to be minimized. The multifaceted nature of the calculation should increment directly as the network develops. Cluster head choice is another significant test that legitimately influences network performance. The most ideal node ought to be chosen so the network strength period and generally, network lifetime ought to be boosted. In a large portion of the techniques, CH determination depends on a few parameters, for example, energy level and the area of the node. Data accumulation is performed on the detected data got by CH from part nodes; that is the reason it is as yet considered as the central design challenge. It ought to likewise be viewed as that the designed clustering calculation ought to have the option to deal with various application prerequisites, as WSN is application subordinate. Another significant factor is to ensure that the designed calculation is sufficiently secure and can be utilized in applications where data is particularly touchy, for example, a military application or health monitoring.

Problem Formulation

The improvement issue is to deliberately refine the testing pace of parts of the whole WSN by computing the difference of the outcomes inspected during timeframes and contrasting it with a limit given by the client. By doing so it is conceivable to lessen the energy consumption of parts of the WSN without significantly harming the exactness of the data that ought to be inspected. Along these lines, (1) the all-out energy consumption for the transmission of every unit of data message from all NCHs to CHs, etc is diminished, (2) the processing energy of the CHs is decreased because of less cycles of inspecting, and (3) the all-out energy consumption of the whole WSN will lessen, and it will be conceivable to expand the WSN lifetime and availability without a moment's delay

We think about the accompanying general suppositions in our concern plan: All sensors are pre-deployed and have obliged energy supply; The network is static, that is, neither the sensors nor the CHs has portability once deployed; The all outnumber of sensors is known; Each CH shapes precisely one cluster, furthermore data processing, likewise plays out a similar errand of natural sensing and data assortment as a customary sensor node; There exists a conflict-free MAC protocol for wireless correspondence. We consider the energy consumption for data transmission of each NCH, and for data accepting, processing, and transmission of each CH. Since the energy cost for condition sensing is commonly substantially less than correspondence and processing assignments, we don't consider sensing energy costs here. Clearly, the all-out energy consumption relies upon the network dispersion, the number, and area of CHs, and the pressure proportion α at CHs.

III. ADHS Algorithm Energy-Efficiency

In this paper, we utilize a logical methodology for computing the estimation of the testing pace of non-stacked pieces of the WSN so as to accomplish improved all out energy consumption of the CHs accepting and processing stages. The complete energy consumption per round, indicated by E_{TOt} is the whole of the energy consumption E_{NCH} of all NCHs for data transmission and the energy consumption ECH of all CHs for data accepting, processing, and transmission in one round, which can be characterized as in Formula (1):

$$E_{Tot} = E_{NCH} + E_{CH}$$

The ENCH just incorporates transmission energy cost ET, when ECH incorporates the energy cost Er for getting, EP for processing, and Et for transmission. Each of NHS moves one unit of data to its relating CH, which performs processing (collection and pressure) on the got data and its own sensing data and sends the compacted accumulated outcome to other CH or BS.

So as to show that our calculation lessens the all-out energy consumption of the entire WSN and not hurt the availability of the network we have to show that (I) the complete energy consumption of the data testing refined zone is really lower than the past state, and (II) that the accuracy of the data that has been inspected is close as conceivable to the genuine data. Accordingly, we need first to figure the energy consumption of the CHs in our model. In light of the past information on ETOt, for each CH in our model the energy consumption will be:

$$E_{CH} = n_{NCH \to CH} E_r + (n_{NCH \to CH} + 1)E_p + \alpha E_t$$
$$= n_{NCH \to CH} E_{elec} + (n_{NCH \to CH} + 1)E_p + \alpha(E_{elec} + \epsilon_{fs} \cdot d_{CH \to HigherCH}{}^2)$$

Where $n_{NCH \to CH}$ Where is the quantity of NCH that speak with the CH, and $d_{CH \to HIGHERCH}$ is the separation between the CH to its higher CH in the hierarchy (the BS is the top node is the hierarchy). Henceforth, a refinement of the sensing proportion in parts of WSN is constantly advantageous if the difference of the data that has been detected doesn't cross the fluctuation limit set by the client, implying that this data is as of now excess and it is gainful to change the sensing proportion and keep away from not so distant future repetitive data. The spare of the energy for a solitary round in this circumstance is finished by diminishing the energy cost EP for processing data, while transmission and getting of data proceed as usual. A detailing of this condition, in view of the recipe (2) to E_{CH} will be:

$$E_{CH} = n_{NCH \to CH} E_r + 1E_p + \alpha E_t$$
$$= n_{NCH \to CH} E_{elec} + 1E_p + \alpha(E_{elec} + \epsilon_{fs} \cdot d_{CH \to HigherCH}{}^2)$$

Subsequently, for a given example rate r ∈ [0,1] the normal energy consumption per cycle, while r doesn't change, for each and every CH will be:

$$E_{CH} = n_{NCH \to CH} E_{elec} + (r \cdot n_{NCH \to CH} + 1)E_p + \alpha(E_{elec} + \epsilon_{fs} \cdot d_{CH \to HigherCH}{}^2)$$

IV. Conclusion

In this paper proposed a distributed algorithm designed to organize sensors into a hierarchical structure of clusters, aiming to minimize the overall energy expenditure within the system while efficiently transmitting the gathered data to the information-processing center. Through our research, we have identified optimal parameter values for these algorithms that effectively reduce energy consumption in the network. The results and analysis lead to the conclusion that employing the ADHS algorithm in conjunction with a differential load algorithm in Wireless Sensor Networks (WSNs) contributes to maximizing network lifetime and ensuring connectivity. This study suggests several potential avenues for future research. One immediate direction is to explore how the ADHS algorithm interacts with various hierarchical clustering algorithms in WSNs, considering factors such as cost, complexity, energy efficiency, and network availability. Another avenue involves optimizing WSN clustering algorithms that do not rely on a hierarchical arrangement, incorporating the ADHS algorithm to enhance their performance. This opens up new possibilities for advancing the understanding and application of clustering algorithms in wireless sensor networks.

References

1. Sachan V, Imam S, Beg M. Energy-efficient communication methods in wireless sensor networks: A critical review. International Journal of Computer Applications. 2012 Feb 29;39(17).
2. Ouafaa I, Jalal L, Salah-ddine K, Said EH. Recent Advances of Hierarchical Routing Protocols for Ad-Hoc and Wireless Sensor Networks: A Literature Survey. In Proceedings of the The International Conference on Engineering & MIS 2015 2015 Sep 24 (p. 32). ACM.
3. Zhang P, Xiao G, Tan HP. Clustering algorithms for maximizing the lifetime of wireless sensor networks with energy-harvesting sensors. Computer Networks. 2013 Oct 4;57(14):2689-704.
4. Lee, J.-S.; Kao, T.-Y. An improved three-layer low-energy adaptive clustering hierarchy for wireless sensor networks. IEEE Internet Things J. 2016, 3, 951–958.

5. Arboleda, L.M. C.; Nasser, N. Comparison of Clustering Algorithms and Protocols for Wireless Sensor Networks. In Proceedings of IEEE CCECE/CCGEI, Ottawa, ON, Canada, 7–10 May 2006; pp. 1787–1792.
6. Kumarawadu, P.; Dechene, D.J.; Luccini, M.; Sauer, A. Algorithms for Node Clustering in Wireless Sensor Networks: A Survey. In Proceedings of 4th International Conference on Information and Automation for Sustainability, Colombo, Sri Lanka, 12–14 December 2008; pp. 295–300.
7. Jiang, C.; Yuan, D.; Zhao, Y. Towards Clustering Algorithms in Wireless Sensor Networks—A Survey. In Proceedings of IEEE Wireless Communications and Networking Conference, Budapest, Hungary, 5–8 April 2009; pp. 1–6.
8. Xu, D.; Gao, J. Comparison study to hierarchical routing protocols in wireless sensor networks. Procedia Environ. Sci. 2011, 10, 595–600.
9. Haneef, M.; Deng, Z. Design challenges and comparative analysis of cluster based routing protocols used in wireless sensor networks for improving network life time. Adv. Inf. Sci. Serv. Sci. 2012, 4, 45
